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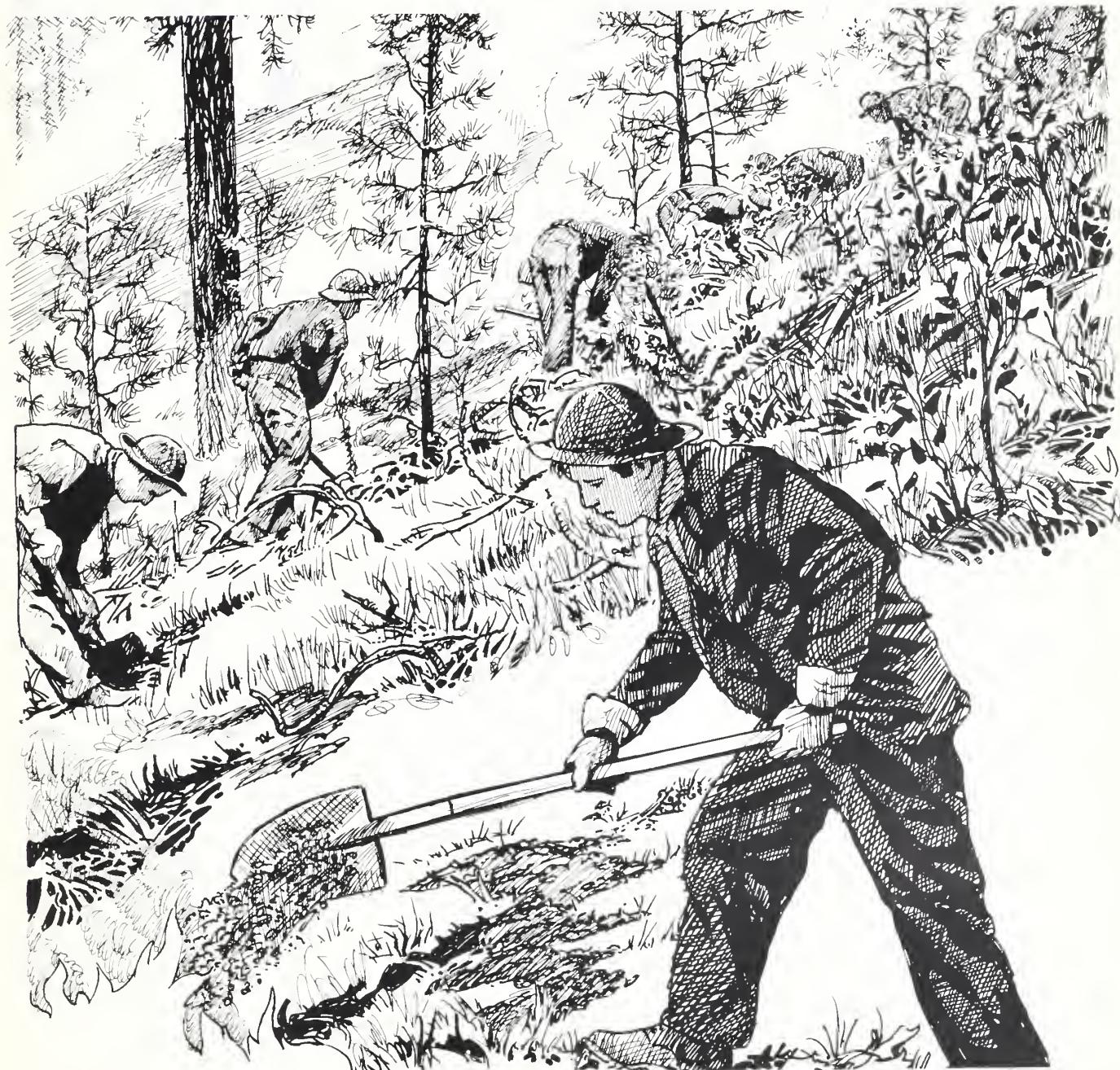
United States
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Volume 44, No. 1
1983

Fire Management Notes



Fire Management Notes

An international quarterly periodical devoted to forest fire management

United States
Department of
Agriculture
Forest Service



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Cover: Building a fire line.

Forest Fire Prevention Education in Virginia Schools

E. E. Rodger

Chief, Forestry Relations, Virginia Division of Forestry, Charlottesville, Va.

Where better to begin a forest fire prevention program than at the beginning. And, to me, the beginning is children. And where better to find lots of children than in schools.

This, then, is a history of the Virginia Division of Forestry's efforts to put together easily conducted, assembly-type forest fire prevention school programs.

Many years ago in preelectric rural schools, forest wardens preached the need to protect the forests from fire to children. Eventually, wires were strung up the hollows and across the flats and the wardens showed up with lantern slide projectors. Later came motion picture machines, flip charts, flannel boards, and other modern teaching devices. Small schools began to consolidate and the number of children coming together in assembly rooms increased.

This meant that more youngsters could be reached in each session. It also meant that the programs had to be of good quality—both entertaining and educational.

An asset to the school program was the fabrication of Smokey Bear costumes. The first costume in the Nation was commissioned by the Virginia Division of Forestry with the Waas Costume Company of Philadelphia, Pa., in 1951. Soon thereafter, the U.S. Department of Agriculture Exhibit Service set up a costume shop and



The narrator sketches pictures while explaining forest fire prevention concepts in the Chalk Talk part of the presentation.



Students learn forestry and fire prevention concepts while student teams play Tic Tac Toe.

Smokey suits became plentiful.

The Division then began in earnest to put together easily transported, easily set up, easy-to-use assembly kits that incorporated Smokey Bear.

As the Division gained experience, the kits improved and today the Virginia Division of Forestry has entertaining and educational assembly kits, which include: two magic sets, Beargo (a type of Bingo), Tic Tac Toe, Football, Smokey's Quiz, Smokey's Matching Game, Beat the Clock, and two Chalk Talks.

The Division has approximately 50 copies of five to seven original kits available for use. Selected kits are used each season; others are retired to wait their turn on the circuit another year.

Developing the kits takes a little time, material, and the skill of an artist for certain parts. Also, every effort is made to make the kits portable so that they fold up into relatively small sizes, are reasonably light in weight, and are fairly rugged to withstand constant use. Once the season starts, there is little time for patching and splicing. The Division provides heavy plastic slip-on cases to help protect the kits. Many times they are hauled in the back of pickups during inclement weather.

How the Program Works

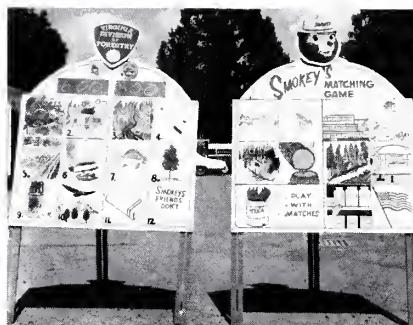
Each of the nine forestry districts decides which assembly kits to use and orders them from State headquarters. The kits are made in the headquarters shop. The districts then conduct training meetings to teach their people how

to use the material. Following the training, teams of two people are designated. The team contacts school officials for assembly dates. An effort is made to schedule two to three schools per day per team. As many as 25 to 30 teams may be putting on programs in the State on some days.

Smokey Bear is always one of the two-person team. The Division has 35 costumes. In addition to the presentation, during the school visit, USDA Forest Service and other suitable materials are distributed.

An important feature of the fire prevention presentations is the involvement of the children in the program. Except for the magic and chalk talk show, the programs are designed for competition. When the forest warden contacts the school official, he asks that six youngsters be selected to form two student teams. The student teams are seated on the stage and become a part of the program. The audience is encouraged to root for their favorites. Scores are kept. Some of the teaching teams manipulate the program so that there are no losers, others let the chips fall where they may.

Within the guidelines of the program, the teaching team may adjust its presentation to the audience level. Also, the teaching team is free to incorporate current environmental messages into the program. Naturally, the thrust of



Student teams match the artwork after the narrator discusses it.

every presentation is forest fire prevention.

The Materials

The magic material is purchased from Abbott's Magic Manufacturing Company, Colon, Mich. The tricks are easy to use and are adapted to forestry messages. The purpose is to use the tricks to get across environmental points.

Tic Tac Toe is easily made and used. Each student team is given

its turn to select an artwork block. The narrator has a series of question cards lying on the ledge under the artwork. If the team gives the correct answer to the question, a large card, X or O, is placed over the artwork. Then it is the next team's turn to try. And so the program unfolds, one team trying to block or beat the other. Usually two to three games are played during the assembly session.

The Beat the Clock program is similar to the once-popular television show. The narrator explains the rules and a student team member is asked to select one of the discs on the clock which identifies the challenge and the clock is set at zero. When the youngster says go—the clock is started. The challenge is to complete the task before 60 seconds have elapsed. The challenges include building a tower using paper cups and plates, carrying a tennis ball in a paper tube, placing animals in their preferred habitat, and the like.

To play Beargo, all the panels are turned with only the numbers showing. From the box a student team member selects a block on which a number is painted. He turns the numbered panel around to display a picture. The narrator talks about the picture to make a forestry point. The next student team member selects a block, rotates the panel, and the game is under way. The game is easily

rigged to have a tie if this is desired.

Football is a popular part of the presentation. Students respond to forestry and fire prevention questions and get a chance to toss bean bags to get additional yardage. The yardage is accumulated by moving the magnetic football down the field. The first student team to get a touchdown wins.

The television Match Game inspired the development of Smokey's Matching Game. Two student teams match artwork that the narrator talks about using Woodsy Owl or Smokey Bear decals.

The Chalk Talk assembly programs require practice and skill on the narrator's part. In each, a story unfolds to make children aware of forestry and environmental facts.

For More Information

Virginia's school program has been warmly received by principals, teachers, and students alike. For more information about the program, contact the Virginia Division of Forestry, Charlottesville, Va. ■

Carbon Monoxide Exposure Associated With Fighting a Peat Ground Fire

Thomas R. Griggs, M.D., David Mage, Ph.D., Ross J. Simpson, Jr., M.D., and Edward Haak, M.D.

Drs. Griggs, Simpson, and Haak are associated with the Department of Medicine, Division of Cardiology, University of North Carolina School of Medicine, Chapel Hill, N.C.; Dr. Mage is associated with the U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Research Triangle Park, N.C.

In May 1981, four firefighters were hospitalized for smoke inhalation during a large brush and peat ground fire in eastern North Carolina. The District Forester organized a team of physicians and air quality specialists to investigate the health effects associated with fighting the fire.

An initial assumption of the team was that the major constituents of the smoke from the fire that would have important health effects would be carbon monoxide (CO) and particulate material. It was felt unlikely that exotic toxins would be involved, since peat moss has been used for fuel for centuries and is not known to exude an especially toxic product during combustion other than CO. Additionally, the people who became ill during firefighting activities were working in dense smoke and at high exertion levels, a situation associated with classic smoke inhalation-CO intoxication syndromes. Therefore, plans were made to measure CO in air samples from around the fire and in blood samples from firefighters working at the fire. The tests were done several days after the injuries had occurred and after the spreading of the fire had been contained. The measured CO and carboxyhemoglobin (COHb) levels reported below are, therefore, believed to be well below the levels that would have been measured

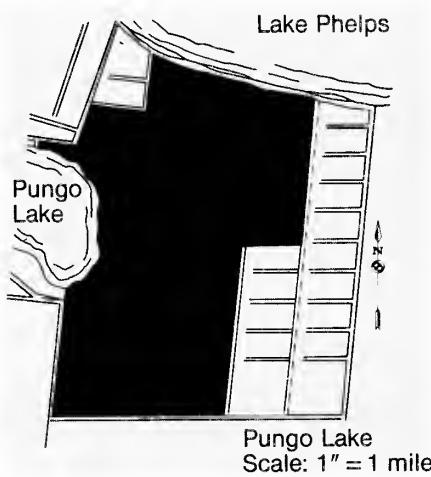


Figure 1.—Map of the fire area.

had samples been taken on the day the injuries occurred.

Methods

Figure 1 is a map of the area of the fire. On the day of testing, the wind was blowing at 5 to 7 miles per hour (mi/h) from northeast to southwest. People working in southern sectors were in moderately heavy smoke that was blowing off the ground fire. People in northeastern sectors were upwind from the fire. The work involved operating pumps or other equipment, and none of the exertion levels was more than moderate. Blood was taken from firefighters and from members of the research team at about 11:25 a.m. and again at 1:35 p.m. Samples were taken from people in

both downwind and upwind sectors. COHb levels were determined by a gas chromatographic method in the toxicology laboratories of the Office of the Chief Medical Examiner of the State of North Carolina. Atmospheric levels of CO were measured with a General Electric CO-3 personal monitor at about the same time that blood samples were taken.

Results (fig. 2)

COHb levels in firefighters in southern sectors were generally higher than those in people in upwind sectors. Smokers in southern sectors had levels of 11 and 13 percent early in the day. These levels fell to about 7 percent 2 hours later. The two nonsmokers had levels of 4 and 5 percent on the early samples and levels of 6 and 7 percent 2 hours later. The smokers reported that they did not usually use cigarettes while they were working in the heavy smoke. Firefighters working in upwind sectors generally had low COHb levels. The one exception was a tractor operator who was working in dense smoke. He was a smoker whose COHb level was 9 percent. The research personnel showed increased COHb levels after approximately 2 hours at the fire with levels going from 1 to 5 percent on an average.

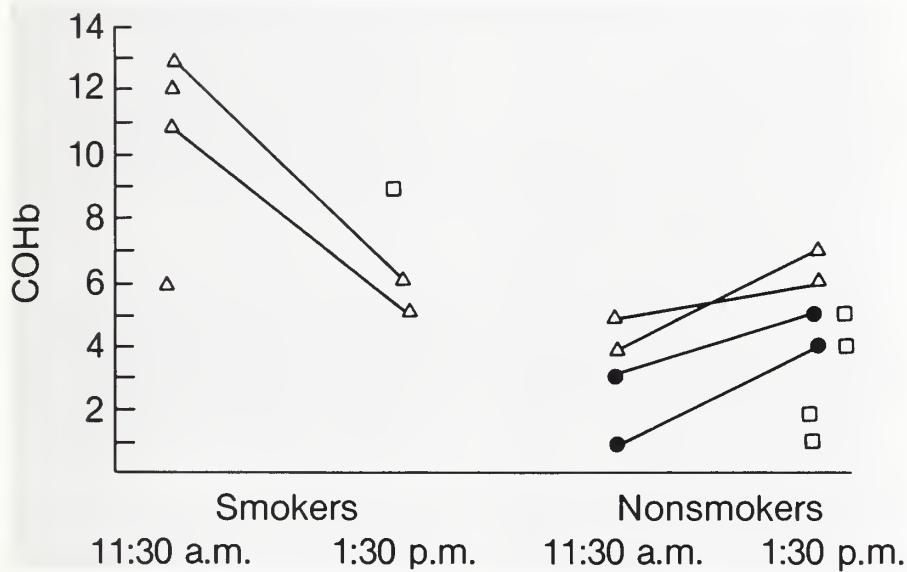


Figure 2.—Carboxyhemoglobin (COHb) levels in firefighters and research personnel on the fire scene. Levels in cigarette smokers are shown on the left; levels in nonsmokers are shown on the right. Points connected by lines represent samples taken from a single person at the two times shown. Triangles = firefighters on the downwind side of the fire (carbon monoxide (CO) about 75 p/m). Squares = firefighters on the upwind side of the fire (CO about 10 p/m). Closed circles = research personnel.

Atmospheric CO levels were highest on the downwind side of the fire, with an average of 75 parts per million (p/m) and a peak of 200 p/m. Measurements on another peat ground fire subsequently have shown levels as high as 500 p/m. Levels in areas upwind from the fire were never higher than 10 p/m.

Discussion

CO is produced whenever carbon is oxidized in the process of burning. Since CO is a product of

incomplete combustion, smoldering fires are usually expected to produce CO in greater abundance than do freely burning fires. Smoldering is especially associated with the ground fire that occurs in peat moss. It should be noted that on the day these tests were done, the fire was entirely confined to ground fire with no open forage burning. These findings documented a potentially hazardous concentration of CO on the downwind side of the fire. As importantly, the findings demonstrated very low levels of CO on

the upwind side of the fire, a situation that means crews could have found a safe haven if they were rotated from downwind to upwind areas during the workday.

In the final analysis, the best indicator of the toxic potential of atmospheric CO is found in the determination of COHb levels of personnel working in the environment of concern. Our assays identified three firefighters, all smokers, who had levels above 10 percent. All three showed lower levels several hours later. On the other hand, workers and research personnel who did not smoke had increasing levels during a 2-hour period at the fire. All levels at the later time were within a range from 4 to 7 percent. Presumably, these levels were near the steady state. COHb levels in this range would be expected for people working in an atmosphere of about 75 p/m of CO. Therefore, the levels of CO in the air were consistent with the blood levels of COHb we observed in people at the fire.

The blood levels that we found, 4 to 7 percent, are high enough to have physiologic effects, but are probably not dangerous in healthy young people. Recognizing that every observer said that the smoke and levels of exertion were both much more intense on the day the firefighters became ill, and judging from our observations that CO

levels correlated with the density of the smoke, it would be reasonable to judge that people working intensively on the fireline in heavy smoke could have had considerably higher levels than we measured 2 days later. Most experts consider COHb levels of greater than 10 percent in persons performing heavy work to be unacceptable. Therefore, it seems probable that personnel working on a peat ground fire in heavy smoke for several hours would accumulate unacceptably high levels of COHb.

It is also important to remember that people with chronic illnesses, especially those with coronary heart diseases, may be injured by levels of COHb lower than 10 percent. Levels as low as 4 percent have been shown to precipitate angina pectoris in susceptible populations, and many structural firefighters who die in the line of duty from heart attacks have been shown to have levels of 8 to 10 percent. Therefore, guidelines for acceptable exposure are applicable only to healthy people. Persons with known heart disease, on the other hand, should not participate in on-the-line firefighting activities where CO levels would be expected to be higher than normal.¹

¹ Most State and Federal wildland fire agencies use the Step test to screen applicants for physical fitness.

It is possible to estimate COHb levels reasonably accurately at the scene of a fire by measuring the CO in expired breath using the CO-3 analyzer (*1*). Such an analyzer, therefore, affords the safety officer the capability to know both the atmospheric levels and, approximately, the blood levels of CO that are affecting the performance and the health of the personnel working at the fire. It is possible, with this information, to make very rational decisions about placement and rotation of crews so that people are used both effectively and safely.

In summary, we measured relatively high levels of CO on the downwind side of a large peat ground fire. These atmospheric levels were associated with elevated levels of COHb in personnel working at the fire. It seems prudent for management personnel responsible for the welfare of firefighting crews at peat ground fires to be aware of the danger that these levels of CO might present. We recommend that safety officers at peat ground fires measure atmospheric levels of CO and CO in expired breath from personnel regularly. If atmospheric CO levels above 100 p/m are noted, personnel should be rotated into low-level areas every 4 hours or so. Further, any firefighter with an estimated COHb level of 10 percent or higher should be moved

to a place where there is low-level exposure. If the equipment for performing CO measurements is not available, rotation of personnel at approximately 4-hour intervals should occur whenever high concentrations of smoke exist.

Acknowledgments

The authors appreciate the assistance of the personnel of the North Carolina Department of Natural Resources, Division of Forest Resources, Derryl Walden, District Forester.

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An Instrument for Measuring Duration of Precipitation

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The 1978 National Fire-Danger Rating System (NFDRS) is being used by all Federal land management agencies and by many fire management organizations. The system contains both a 100-hour and a 1,000-hour timelag fuel-moisture prediction model. The key parameters in both prediction equations are the equilibrium moisture content and precipitation duration (1). These fuel moisture predictions are essential in determining the components of NFDRS behavior and occurrence. Consequently, the establishment of accurate data on precipitation duration is an important element in the NFDRS.

Today, when recording precipitation gages cost \$500, operators of most fire-weather stations use operational estimation to determine rainfall duration. This method, however, is particularly vulnerable to error if rainfall occurs during the night or if the station is located at a remote site visited at 24-hour intervals. This paper discusses the design and implementation of a simple, inexpensive, and durable precipitation gage that could be used at most fire-weather stations.

Design

The instrument consists of a collector, sensor, d.c. battery power source, and a strip-chart recorder, which allows it to remain unattended for 10 days. It has

design features similar to an existing precipitation meter developed by Daniel W. Barnes (4). However, it has a simpler construction and a much lower power requirement than the Barnes design.

The collecting apparatus is a plastic funnel housed in a cylindrical, galvanized stovepipe (fig. 1A). The sensor consists of two brass strips attached 0.10 inch (0.25 cm) apart on the spout of the funnel. A double insulated wire fastened to each of the two metal contacts connects a d.c. battery to a Rustrak microampere strip-chart recorder. A resistor is placed between the battery and the recorder to eliminate the possibility of a current overload to the recorder's galvanometer. A psychrometer wick is positioned between the two sensor strips and allowed to drape downward.

As the precipitation droplets collect and descend along the funnel walls, they come in contact with the metal strips and complete an electrical circuit. A current flows from the battery to the microampere-detecting meter of the recorder. When precipitation stops, the wick draws the water from between the brass strips and breaks the electrical circuit.

Construction

The sensing unit, which includes the stovepipe and funnel, can be

constructed in less than 2 hours with materials costing under \$4. The plastic funnel collector is encased in a galvanized stovepipe (see fig. 1B). Three holes drilled on each side of the pipe enable support stakes and the funnel to be secured in position.

The tips of a two-pronged brass paper fastener serve as the metal sensing strips. Each of the two sensing strips is attached to the funnel spout with waterproof, non-conducting epoxy glue. A 0.10-inch (0.25-cm) gap is left between the sensors.

A length of double insulated wire is soldered to each metal sensor. A thin cotton psychrometer wick is then positioned onto one of the two metal sensors. A small portion of the wick is allowed to extend into the gap but not to touch the second contact (fig. 2A and 2B). A short piece of wire left extending from the solder joint can be used to hold the wick in place.

Installation

After positioning the gage at the weather station site, push the insulated sensor wires through a 0.25-inch- (0.64-cm-) diameter hole drilled through the stovepipe casing. Attach the wires to the recorder and 6-volt d.c. battery as shown in figure 1A. A 60,000-ohm resistor placed between the 6-volt battery and the recorder eliminates the possibility of a current overload to the galvanometer. A 12-volt marine

battery, recharged every 2 weeks, may be used as a power source to operate the strip-chart motor efficiently.

- 1 plastic funnel
- 1 galvanized stovepipe
- 3 brass, 2-pronged fasteners
- 2 wooden support stakes
- 4 attachment bolts
- 1 6-volt d.c. dry cell battery
- Waterproof, nonconducting epoxy glue
- 1 12-volt d.c. marine battery
- 1 60,000-ohm 1/2-watt, 5-percent resistor
- 1 d.c.-powered microampere strip-chart recorder
- Double insulated wire
- Solder

Currently, the cost of the equipment is under \$200, and a current-detecting switch that activates a battery-powered clock is presently being tested. The switch will reduce the total cost to under \$20 by eliminating the strip-chart recorder. Since the NFDRS requires precipitation duration for a 24-hour period only and weather observations are generally taken once a day, this clock recorder would satisfy the needs of most fire-weather stations.

Results

The precipitation gage was placed in a clearcut adjacent to a Belfort weighing rain gage in western Washington (fig. 3).

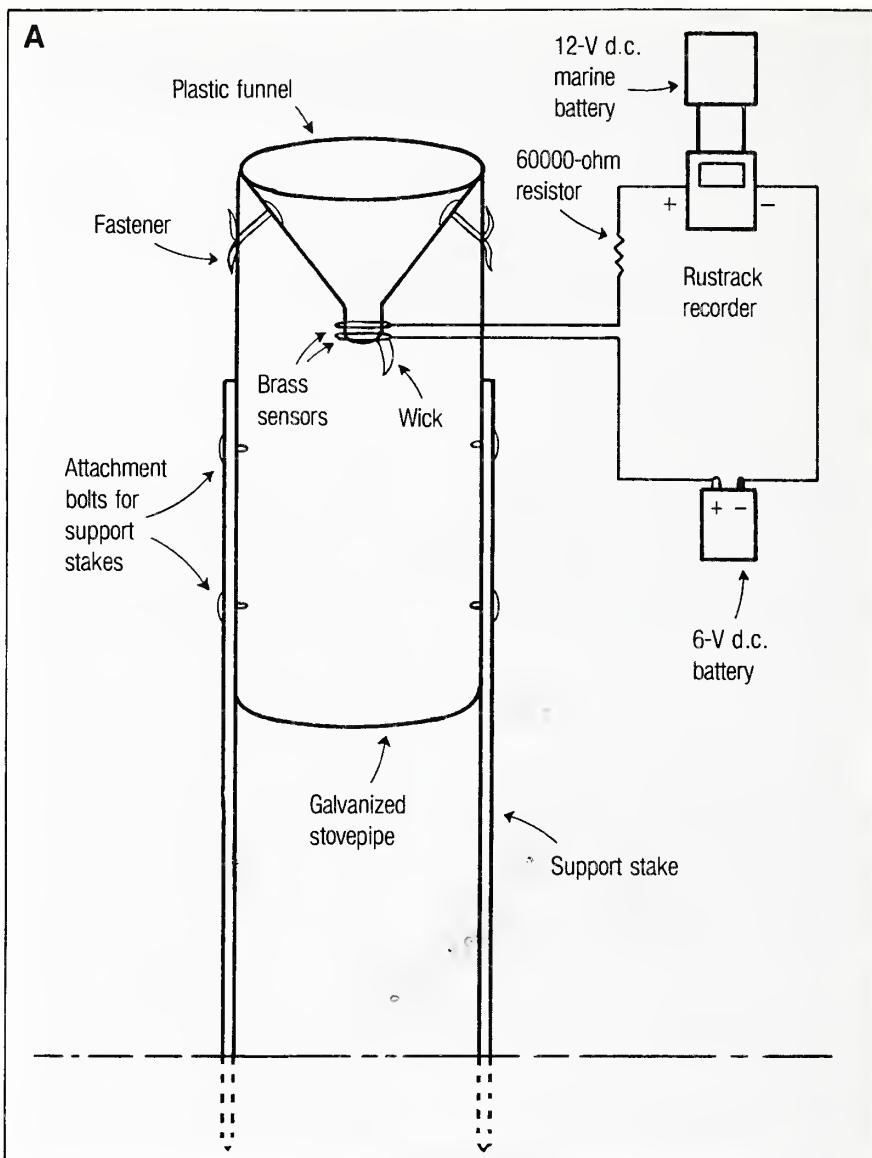
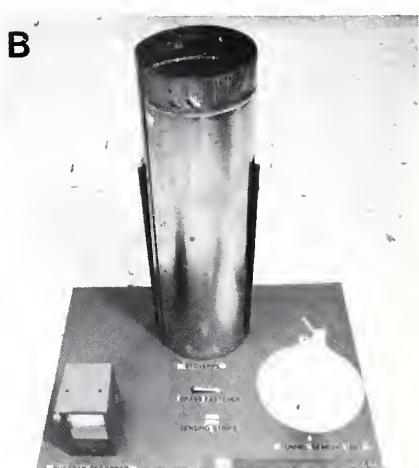


Figure 1.—(A) The collecting apparatus is a plastic funnel housed in a cylindrical, galvanized stovepipe. (B) Support stakes through three holes drilled on each side secure the funnel.

During the 3-week test period, 10 major precipitation events occurred. Figure 4 displays a chart from each instrument. Table 1 gives the number of hours of each event as determined by the two instruments.

The precipitation gage corresponded well with the recorded times rain fell as noted by



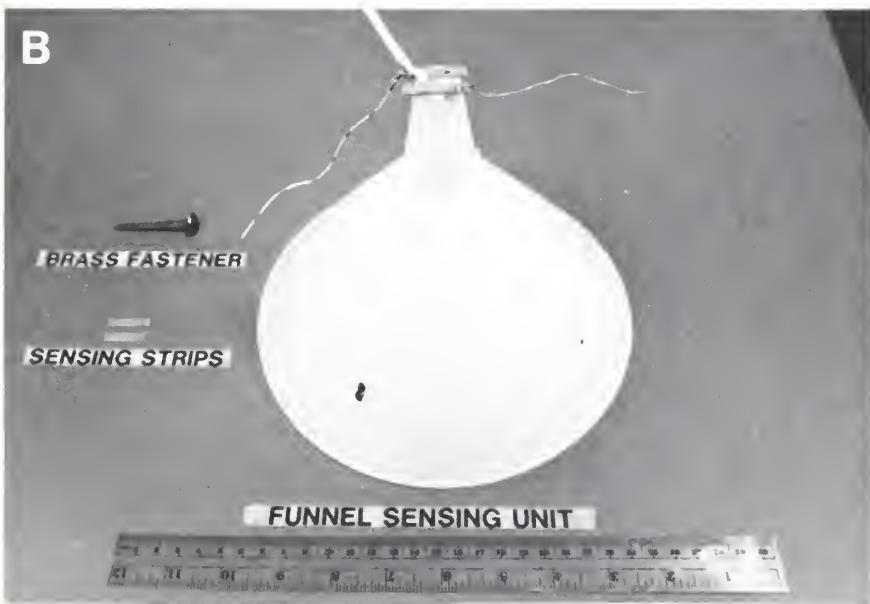
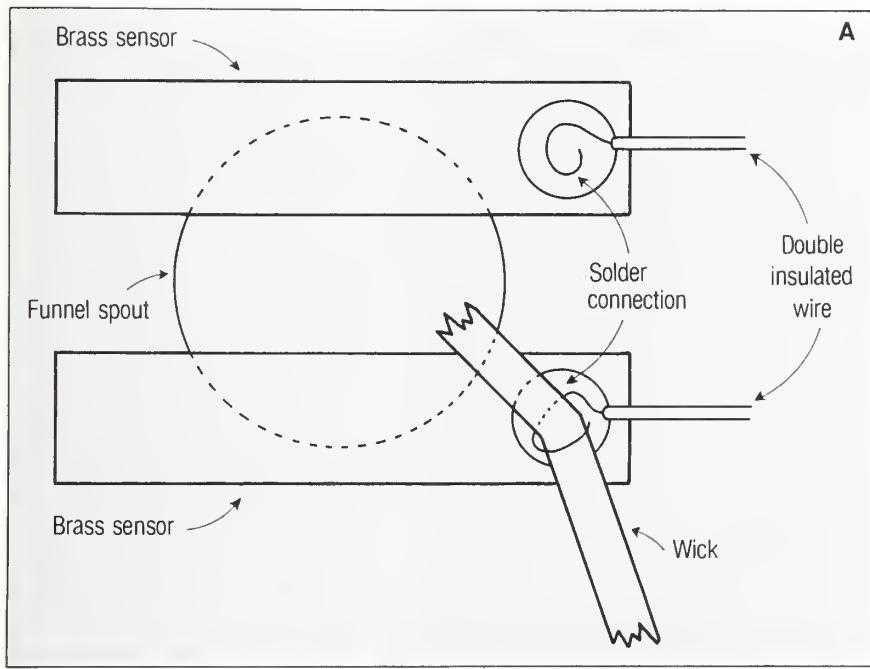


Figure 2.—(A) A drawing of the funnel sensing unit. (B) The parts of the sensing unit.

the Belfort gage (table 1). Since the weighing type instrument is sensitive only to rainfall magnitudes of 0.01 inch (0.25 mm) or greater, this instrument will not detect light rain or drizzle. The precipitation gage, on the other hand, will record such precipitation. This higher degree of sensitivity accounts for the increased duration recorded by the precipitation gage.

Positioning the Instrument

Like any other precipitation measuring device, the duration gage should be positioned in an open area, away from buildings and trees. It should be leveled on level ground, plumbed, and made windproof (2). The distance away from every surrounding object should be not less than two times the height of the object above the rim of the gage (3). A screen



Figure 3.—The experimental gage was placed in a clear cut adjacent to a Belfort weighing rain gage.

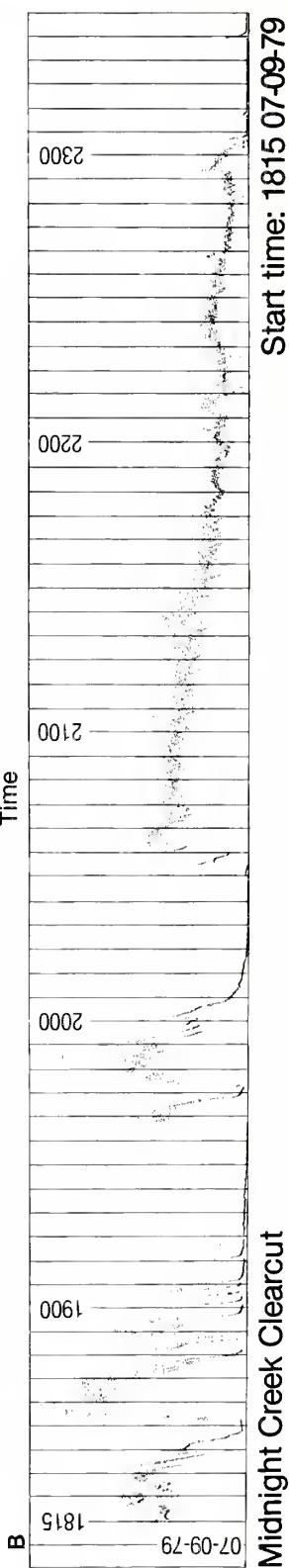
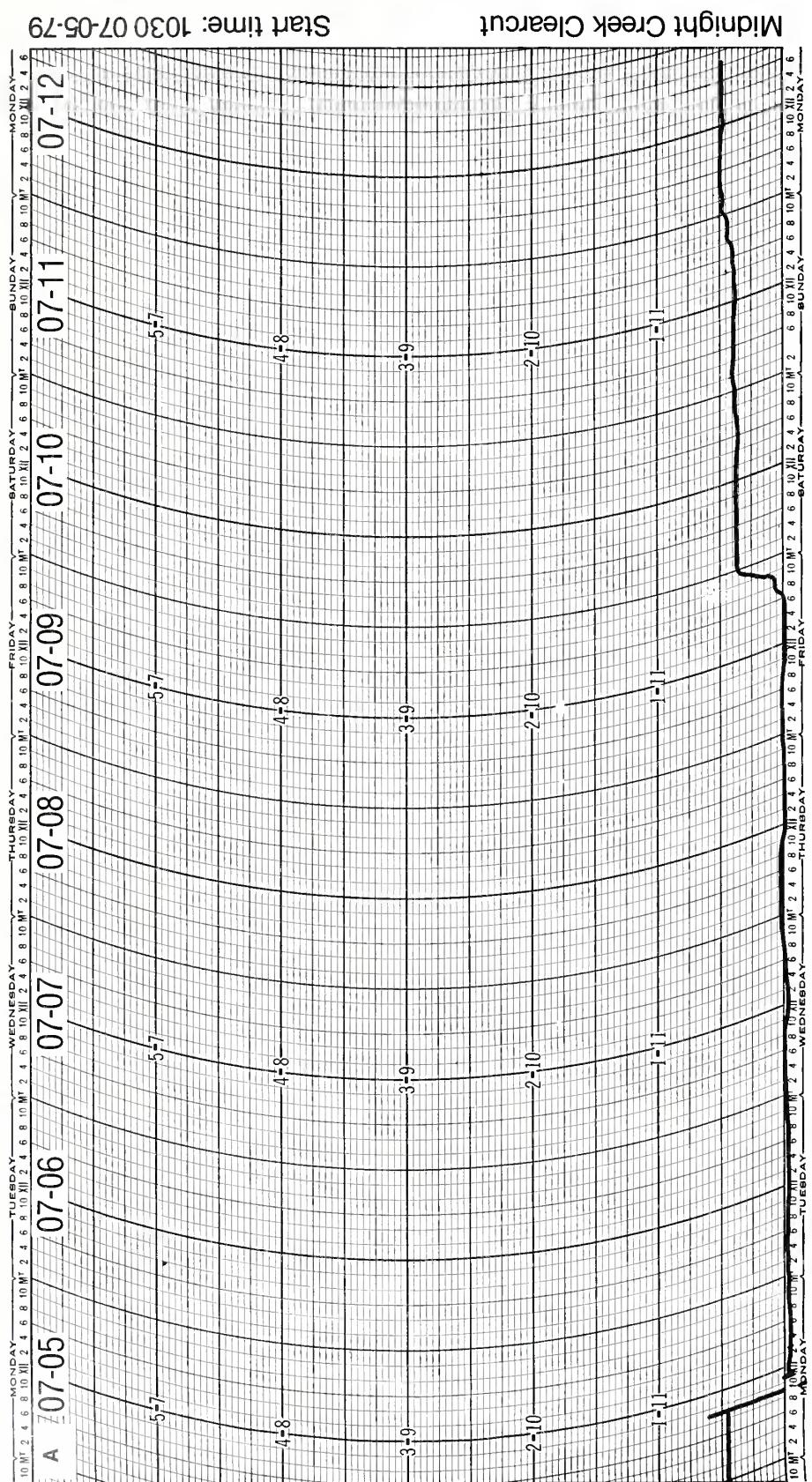


Figure 4.—Charts from the experimental test gage and a Belfort rain weighing gage.

positioned over the funnel will prevent foreign objects from entering the funnel spout and shorting across the sensor strips.

Advantages

The ability to operate on d.c. power enables this instrument to be placed at a remote site. The simplicity of the design makes the apparatus durable and easy to install. The instrument has an increased sensitivity and improved accuracy over more expensive equipment. Furthermore, the sensing unit costs under \$4 to construct. Although a strip-chart recorder adds approximately \$150 to the apparatus, a current-detecting switching circuit is being tested which may eliminate the need for this expensive piece of equipment.

Applications

The success of the precipitation gage in providing rainfall data for NFDRS component computations suggests many applications useful to the fire manager. When the precipitation gage is established alongside a hygrothermograph, fuel sticks, and windspeed indicator, a nearly complete fire-danger record can be obtained.

Table 1.—Occurrences of precipitation recorded by the duration gage and the Belfort weighing rain gage

Date	Precipitation			
	Approximate time		Duration	
	Begin	End	Experimental gage	Belfort gage
----- Hours -----				
June 30, 1979	1000	2000	10.4	10.0
July 1, 1979	0600	0800	2.2	2.0
July 1, 1979	1000	2000	10.0	10.0
July 4, 1979	0030	0230	2.8	2.0
July 4, 1979	0830	0930	1.2	1.0
July 9, 1979	1800	2330	4.0	3.5
July 10, 1979	0130	0308	1.0	1.0 ¹
July 10-11, 1979	2300	0200	2.5	2.5
July 12, 1979	1600	2000	4.3	4.0
July 11-12, 1979	2330	0230	3.0	3.0
Total			41.4	39.0

¹ Although the Belfort gage recorded less than ½-hour precipitation duration, 0.02 inches (0.51 mm) accumulated in the gage. The NFDRS rules specify that a 1-hour duration be assigned to precipitation greater than a trace.

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WOODY II—A T.I. 59 Program To Process Downed Fuel Inventory Data

Joseph M. Glassy

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Several programs are currently available to help fire managers process and interpret downed fuel inventory data. A program maintained at the Fort Collins Computer Center called DFINV offers the user an in-depth analysis of the data. Other options now include WOODY II, various other microcomputer and programmable calculator programs, and a manual method described by Brown (1).

This report describes WOODY II, an interactive calculator program designed for use on the Texas Instruments T.I. 59 calculator with printer. WOODY II offers fire managers an easy-to-use "medium resolution" alternative to existing programs. With WOODY II, data can be processed in the office immediately after it has been collected, and made available for prescribed burn plans, district fuels management plans, or forest level fire management plans. Personnel with little or no experience in data processing can learn to run the program using the User's Manual and documentation which accompanies it.

WOODY II differs from existing calculator programs in how the data are organized, its streamlined data entry system, its choice of output levels, the types of statistics available, and its operation prompt card.

Data organization: Data are processed on a plot basis rather than by fuels size class. This enables statistics to be easily calculated for a group of plots.

Data entry: A new, streamlined data entry system enables rapid entry of all items, and has built-in counters to inform the user when all plot constants such as quadratic mean diameters have been entered.

Output levels: A choice of three output levels, varying in length, allows users to tailor the output format to their specific needs.

Statistics: Descriptive and error statistics are available for a given set of plot data. This includes confidence interval limits, from a choice of 90, 95, or 99 percent, for the mean total tons per acre for the group of plots.

Operation prompt card: This card fits on the T.I. printer; it summarizes all operations of the program, and defines all output levels and output codes.

Input Requirements

WOODY II input consists of plot by plot entry of raw data read directly from the standard fuel inventory data form (1). Quadratic mean diameters, found in the appendix of the User's Manual, only need to be entered once for each group of plots.

Program Output

The format of the output is specified by the output level chosen at the start of the program. Additional copies of the same output, or different output levels, may be selected after the first output is printed.

Users may choose from three output levels, ranging from a short distribution of the fuel loadings (tons per acre) for the 0-.25 inch, .25-1 inch, 1-3 inch, and 3 inch + sound and rotten fuel size classes, to a complete summary which includes the above plus the mean duff and fuel depths, mean 3 inch + sound and rotten fuel piece diameters, and descriptive statistics for the group of plots.

Statistics for the total mean tons per acre include mean, standard deviation, percent standard error, and a choice of the three confidence intervals listed above.

User Support Service

One drawback to many calculator programs available today is the lack of adequate program documentation and user support. In addition to the comprehensive User's Manual which comes with WOODY II, a user support service is offered to registered owners of the program. This service allows users to call or write for answers to program-related questions on

operation, magnetic card writing and storage, and for general troubleshooting assistance.

Availability

Copies of WOODY II are available through Systems For Environmental Management (S.E.M.), a private, Montana-based nonprofit research organization. A complete WOODY II package consists of a User's Manual, Program List, and prerecorded magnetic cards bearing the program. Since the program is fairly long (631 steps), many users may prefer to use the prerecorded magnetic cards, which eliminate the need to key in the program each time it is used.

For additional information write or call:
WOODY II, Attn: J. Glassy,
Systems for Environmental
Management, P.O. Box 3776,
Missoula, MT 59801, (406) 549-
7478.

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An Attempt To Limit Wildfires Through Prescribed Burning Assistance

James B. Whitson¹

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The Florida Division of Forestry (FDF) received a national initiative grant to evaluate prescribed burning as a fire management tool from the U.S. Department of Agriculture, Forest Service. The FDF provided free prescribed burning assistance to landowners in a county of high fire occurrence and evaluated its effect.

Collection of Data

Florida fire statistics were used to determine which county and which area within the county would be used in this project. Since the statistics did not break out by county it was necessary to go through each fire report for the county.

Figure 1 shows that for the years 1975-79 incendiary fire was the largest cause of fires occurring in Clay County in the Jacksonville District. Figure 1 also shows that Clay County was far above the Florida average in each of these years for incendiary fires. In fact, the northwestern portion of Clay County became the site of the experiment, because of the high occurrence of incendiaryism. Statistics also indicate that approximately 75 percent of all fires are caused by local residents.

It should be noted that in 1978 the number of incendiary fires in Clay County declined, because the District Forester decided to let certain fires burn. Since large acreage burned in the area, the number of fires decreased. This indicated that an active program of fuel management would work.

Clay County Fire History

Historically, fire has been used in cattle grazing in northwest Clay County. Open range areas were not fenced and were burned every year to hasten green-up in the spring. The burned areas acted as fences, because the cattle grazed only where there was lush green grass.

Although most of the open range cattle farming ceased by the late fifties, local residents continue to burn large areas of the county.

Incendiaryism in this area has always been a problem. Many large landowners attribute fires they experience to local residents who resent take-overs of large tracts of land. Generally, these fires do not damage standing timber; however, the potential for destruction is there.

Considerable effort is expended by the FDF in responding to these incendiary fires. Prescribed fire gives the FDF the advantage of burning under controlled conditions.

Climatological Summary

Clay County is near the northern boundary of the trade winds. The terrain is level and easterly winds produce a maritime influence that modifies, to some extent, the heat of summer and the cold of winter.

The greatest rainfall, mostly in the form of local thundershowers, occurs during July, August, and September, when a measurable amount can be expected on about half the days. Rainfall of an inch or more in 24 hours will occur about 14 times a year.

The atmosphere is moist, with an average relative humidity of about 75 percent during the afternoon. The average daily sunshine runs from 5.5 hours in December to 9.0 hours in May.

Pervading winds are from the northeast in the fall and winter months and from the southwest in spring and summer. Wind movement averages slightly less than 9 mi/h, 2 to 3 miles higher in the early afternoon than the early morning hours, and slightly higher in spring than in other seasons of the year.

June, July, and August are the hottest months, with temperatures averaging above 80° F. December, January, and February are the coolest months with mean temperatures near the middle fifties.

¹Now on assignment with U.S. Department of Agriculture, Forest Service, Boise Interagency Fire Center, Boise, Idaho.

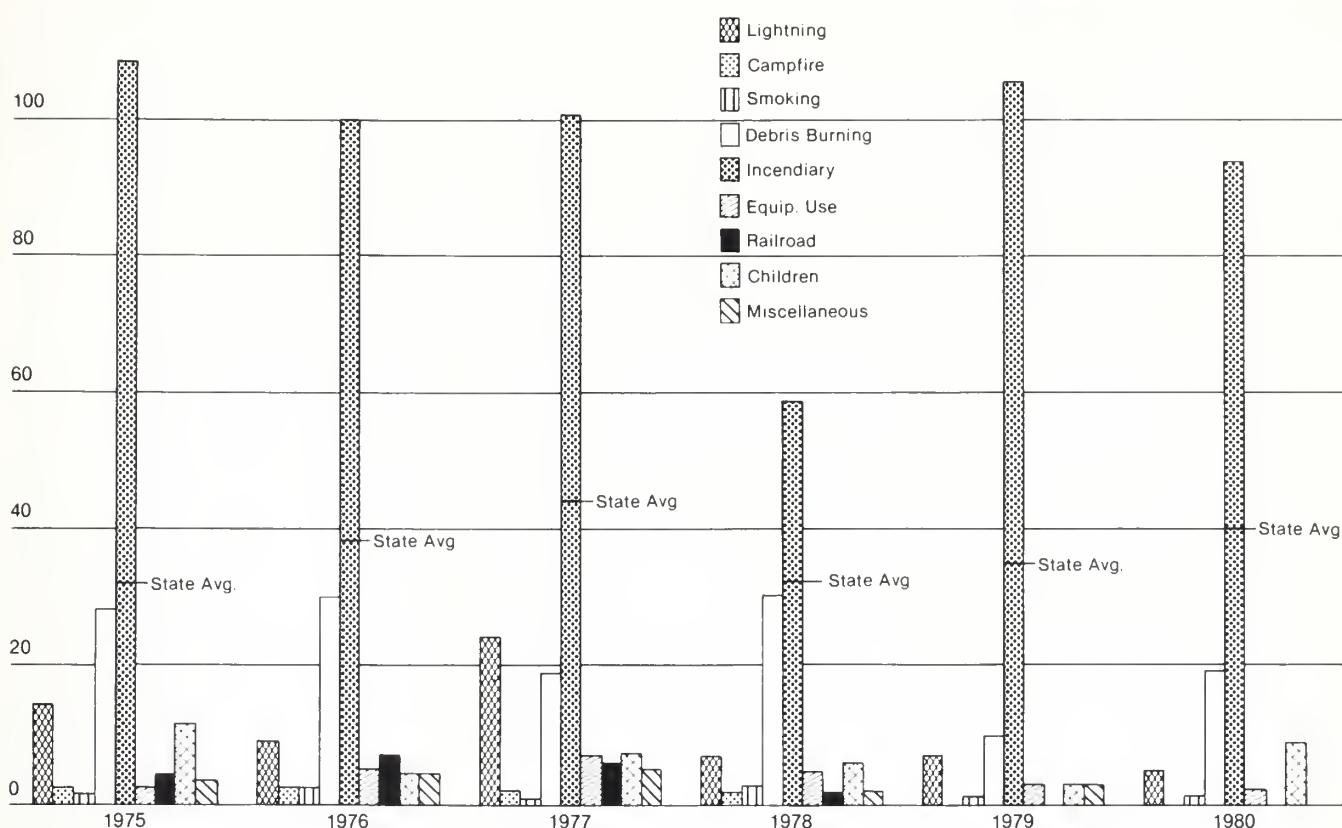


Figure 1.—Fires by cause in Clay County, Fla., from 1975 to 1980.

Methods

A prescribed burning package that included all plowing and burning and cost \$2.40 per acre was offered to landowners from September 1979 through November 1979. The landowners who agreed to participate in the program signed agreements relieving the FDF of any liability for losses, injury, or damages to their property. A prescribed burning plan was prepared by a forester in conjunction with the fire supervisor. All burning was done with FDF crews following the prescription as closely as possible.

Plowing and burning originally were scheduled for September

through November 1979; however, the extremely wet fall resulted in an extension through January 1980.

Approximately 150 miles of fireline were constructed and 4,720 acres were burned on 10 land holdings.

Results and Conclusions

The fire occurrence data for 1980 for Clay County are shown in figure 1. The statewide average of incendiary fires by county increased from 35 in 1979 to 40 in 1980. The number of incendiary fires in Clay County decreased from 107 to 94 for the same years.

This change may not be statistically significant, but is in the proper direction. While it is not practical to believe that fuel management alone will solve an incendiary problem, a balanced program of fuel management, fire prevention, and aggressive law enforcement should substantially reduce fire occurrence in a problem area.

The FDF has established a statewide program to make prescribed burning available to the private woodland owner when other burning assistance is not available. ■

Living With Lightning

Donald M. Fuquay

Research Meteorologist (retired), USDA Forest Service, Intermountain Forest and Range Experiment Station, Missoula, Mont.

Lightning, one of nature's most spectacular displays, poses a serious threat to people, animals, and property. It kills several hundred people in the United States and causes most of the wildland fires that occur in the western United States and Alaska every year.

Many, if not most, of the lightning accidents involving people, however, could be avoided, if people understood lightning enough to protect themselves from it.

Where and When Lightning Strikes

Analyzing records of lightning accidents indicates where and when the chance of being struck by lightning is greatest. The available records, however, are incomplete because fatalities during house and wildland fires, munitions and oil tanker explosions, and aircraft disasters are usually not recorded as lightning fatalities and injuries, even when they are caused by lightning. Also, lightning accidents usually involve only one to three persons and are only reported in the local news media. Some events, however, do attract nationwide attention. For example, millions were listening when the Apollo 12 space vehicle triggered two lightning flashes during launch which cut out the onboard computers and guidance systems.

Airline crashes in Florida and Maryland attributed to lightning received national attention, as did the emergency shutdown of a nuclear power plant caused by lightning.

Statistics indicate that the risk of being struck by lightning is closely related to the living, working, and recreational habits of the individual. Most lightning accidents occur in early afternoon during June, July, and August. People working outdoors such as farmers, ranchers, and heavy equipment operators make up about one-third of the casualties. Among recreationists, people boating, fishing, swimming, golfing, and camping head a long casualty list.

Situations during which lightning accidents occur fall into five categories. In descending order of importance, they are: under trees, on open water, near tractors, on golf courses, and on telephones. About one-third of lightning fatalities occur under trees (usually isolated ones) on the golf course. The open water incidents involve people swimming near beaches, standing on piers or levees, or boating in small crafts. The tractor group includes people struck near farm tractors and implements, construction equipment, and cars and trucks. The golf course incidents involve golfers who were not under trees when they were struck. Telephone incidents occur

on long rural lines, which are particularly vulnerable to lightning strikes.

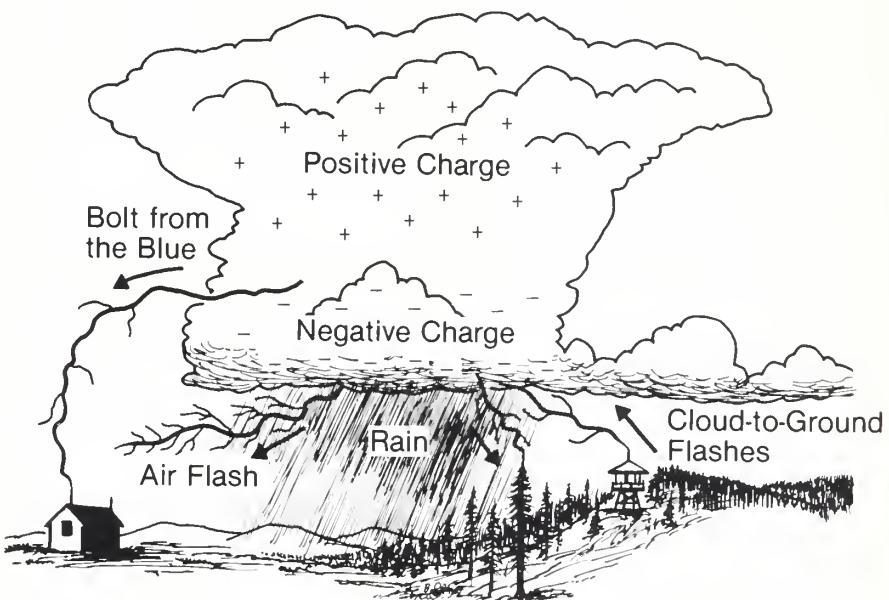
There is only a small chance of being injured by lightning in a modern home or building. City dwellers are particularly safe, mostly because of the tall buildings and the sheltering effect of steel frame construction and grounded powerlines. The risk is a little higher around suburban houses, barns, and sheds with inadequate lightning protection. Unprotected rural buildings and haystacks are quite vulnerable to lightning-ignited fires. Barns and sheds with metal roofs are particularly dangerous when not grounded. Lightning near tobacco-drying sheds with corrugated metal roofs has claimed many victims. One category of rural accidents stands out because the accidents could be so easily prevented: Long rural telephone lines are especially vulnerable to a direct strike. To be safe, stay off the telephone during thunderstorms.

The records of lightning accidents clearly show that death and injuries occur when a person is struck directly by lightning or comes in contact with material that is carrying the lightning current. A fundamental rule for personal protection is to avoid becoming a lightning rod or part of the lightning circuit.

How Lightning Is Generated

On a typical thunderstorm day, small cumulus clouds form near noon time and continue to build during early afternoon. As they grow, they begin to resemble gigantic cauliflowers, and their tops appear hard and bright. Inside, condensation of water vapor causes large drops and ice particles to form. When these particles become large enough they fall through the updrafts and eventually emerge as rain. The falling water and ice particles, by processes not yet fully understood, cause a negative electrical charge to accumulate in the lower part of the cloud and a positive charge to accumulate in the upper part.

The negative charge in the cloud base attracts a large positive charge in the conducting earth below the cloud. The ground charge grows with the strength of the cloud's negative charge and faithfully follows the cloud as it moves over the ground. Picture a positive charge flowing to the upper limits of hills, rocks, buildings, or people—anything that can conduct the electricity a little closer to the cloud. The charges, attracted by million-volt electric fields, strive to break down the electrical resistance of the intervening air. When this resistance is finally overcome, a lightning flash results.



Typical cloud-to-ground lightning. The arrows indicate the direction of the lightning leader.

Lightning can span the distance between the charge centers within the cloud or between the negatively charged lower portion of the cloud and positively charged objects on the earth. The latter occurrence is the one that does all the damage. The lightning discharge usually begins with a downward-moving spark, called a stepped leader, traveling in a series of luminous steps about 50 yards long toward the ground. This negatively charged leader prepares an ionized, electrical conducting path. It may follow a tortuous path, sending

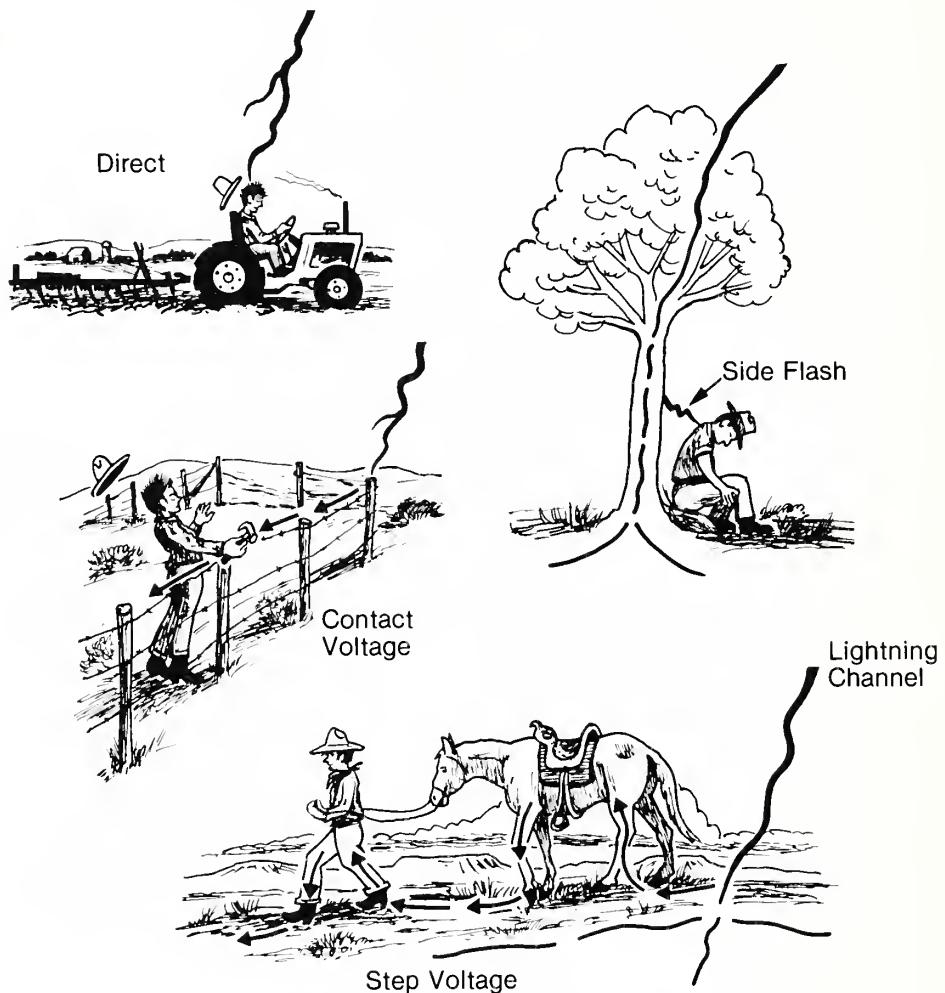
out branches to the side to intercept small pockets of positive charges along its course. As soon as contact is made with the surface, a surge of current in the channel creates the bright flash of the return stroke. The leader has made its descent in 20 to 30 thousandths of a second, and the return stroke lasts only a few millionths of a second. Additional return strokes—most flashes have three or four—may follow at intervals of 30 to 40 thousandths of a second. In some cases, the return stroke may develop a continuing current tail that lasts for

several tenths of a second at a low current level. These continuing current tails, much like a welder's arc, cause major damage at the contact point, including explosions and fire. The leader and return strokes usually happen so fast that the eye detects only a single flash of light. Most lightning flashes are over in the blink of an eye.

Thunder is produced by the lightning return stroke. The return stroke current follows a channel less than an inch in diameter, within which the temperature may reach $50,000^{\circ}$ F. The sudden temperature rise causes a rapid expansion of the channel gases, creating a sound wave radiating outward at roughly 1,000 feet per second, or 1 mile in 5 seconds. Since the lightning flash occurs at the instant of the discharge, the time that elapses until the clap of thunder may be used to estimate the distance to the strike point. A thunder delay of 15 seconds, for instance, would indicate the lightning was about 3 miles away.

How Lightning Is Conducted

When the lightning channel nears the ground, connecting streamers reach upward from the tips of grounded objects. The first streamer to make contact, called a connecting leader, completes the electrical circuit and receives the surge of lightning current. A connecting leader from a lightning



A person can be injured by a direct strike by lightning, by contact with a conductor carrying the lightning current, by a side flash from a struck object, or by a step voltage from current passing along the ground from a nearby strike.

rod can easily reach out and intercept lightning falling within a distance of about twice the rod height above the ground. Thus, a lightning rod, tower, or building gives a zone of protection of about a 60° angle from its top. Within this space, the lightning will be drawn to the rod.

The lightning current follows the path of least resistance to neutralize its charge. Although concentrated in the earth directly beneath the cloud, the bound positive charge may extend miles in all directions. The path of the lightning current depends on the nature of the surface it strikes. Moist soil easily conducts the lightning current. Lightning on very dry or rocky soil may travel along the surface or flash into the air for several tens of feet.

Trees or unprotected wood buildings that are struck may be shattered and catch on fire. A lightning strike to a dry, rocky slope may travel along the surface in sheets following channels and crevices, over and around blocks, across voids in the rocks into moist crevasses.

Human and animal bodies are good conductors of electricity: not as good as a copper rod or wire, but better than air, wood, rock, or dry soil. Physiologic responses to an electric current depend on its path through the body and the

strength and the duration of the current. Relatively small currents passing through the brain stem and downward along the spinal column cause respiratory arrest. Current through the chest causes circulatory arrest and heart fibrillation. A modest current through the lower torso or across the legs can cause muscle spasms and temporary paralysis of the lower body. Large currents flowing through the limbs can result in serious burns without causing loss of critical body functions. After the current has stopped, a struck human or animal presents no danger because no residual charge remains.

How Lightning Strikes

Lightning strikes people and animals in four ways: by direct strike, by contact voltage, by side flashes, and by step voltage. Fatal injuries invariably occur from direct strikes when the body becomes the lightning conductor. Lightning striking a tractor driver in an open field, a golfer on the green, or a climber on an isolated point are examples of direct strikes. Chances for survival are low when the body carries the full force of the lightning discharge; higher when the body carries only the initial streamer. When lightning strikes a group of people, one or two will often be killed while others are only stunned or temporarily paralyzed.

Contact voltage enters the body when there is direct contact with the conductor carrying the lightning current. Any conductor carrying a current develops a voltage difference along its surface proportional to the current surge. People touching conductors have part of the current diverted through them and into the ground. For instance, a person leaning on a metal fence or touching a plumbing fixture when lightning hits may experience lightning by contact voltage. A farmer handling irrigation pipe might experience a contact voltage or a direct strike depending on how close the lightning hits.

Sometimes voltage in a lightning conductor is powerful enough to cause a spark to jump across open air to an alternate conductor. The side flash, an unpredictable form of lightning, endangers people standing close to anything carrying the lightning current. People or animals close to a struck tree, a piece of construction equipment, the side of a house, or near a stove with metal smoke pipe are often victims of side flashes. Lightning surging through electrical systems in homes can spark explosively from wiring within the walls or from nearby electrical appliances. Rural telephone lines can carry a lightning-induced voltage that leaps from handset to ears or faces. Many incidents of side flashes involve tent occupants injured by

lightning strikes through tent poles.

Electric current traveling through the ground can injure people and animals several hundred feet away from the contact point. In dry soil, step voltage may even produce sparks that flash into the air. A person walking or standing with legs apart would receive a paralyzing jolt through the lower body. Many serious physical injuries come from falls following a paralyzing shock. Postures with both hands and legs touching the ground could lead current through the torso. A person prone in a damp sleeping bag could receive current along the length of the body. Step voltage can be avoided by limiting contact points with the ground. A crouching or kneeling position with limbs close together is recommended. Crouching on an insulated surface such as a climber's coiled nylon rope or a dry knapsack will also help. An injured person trapped in an exposed area might be wrapped in a metal-coated survival blanket or an aluminized fire tent to form a protective cocoon of conducting material.

Large animals are very vulnerable to step voltage both because of their length and the position of the organs within the body. Groups of cattle, elk, sheep, and horses have been killed by this type of current.

For instance, many strikes to cattle ranch hands in the saddle kill the horse, but do not injure the rider. In these cases, the horse was a victim of a step voltage. There are also cases, however, where the rider is the victim and the horse survives. Occasionally, both are killed.

Myths and Misconceptions About Lightning

The most persistent myth about lightning is that it never strikes twice in the same place. In fact, not only can lightning strike the same spot more than once, it can do so during a single storm. Prominent points or structures may be struck many times during a year.

As a thunderstorm moves across the terrain, the lightning moves with it. Nonetheless, the fact that a storm has passed does not mean that the threat of lightning has passed. In fact, there are many instances of lightning striking miles from the boundaries of the cloud, which validates the expression of "a bolt out of the blue."

Some people believe you can always see a lightning storm coming. This is often true, but not always. Many accidents occur when the victims are caught by surprise because lightning appears suddenly. Quite often a storm will build quickly overhead and the first lightning bolt is the fatal one.

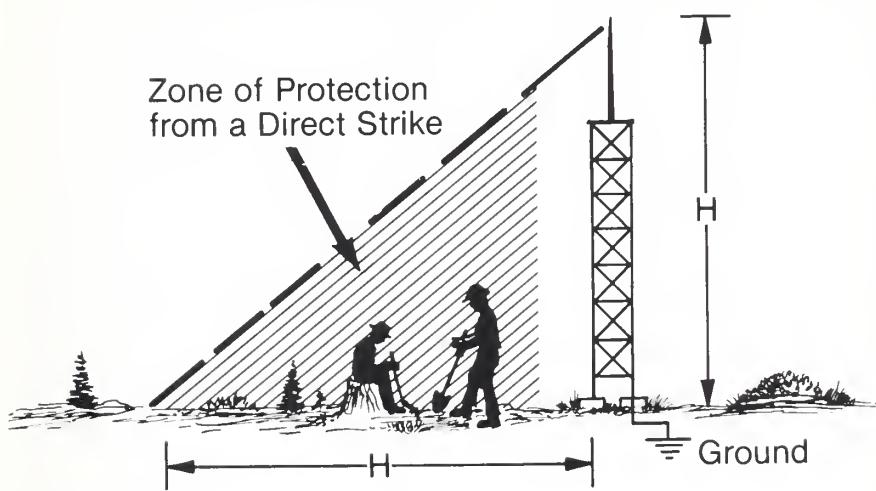
Other dangerous misconceptions involve cars and rubber tires. Vehicles with metal tops are excellent shelters from lightning, because the metal of the car conducts the lightning current around the people safely tucked inside—not because rubber tires insulate the car from a lightning strike. Lightning, after traveling miles through insulating air, has no trouble flashing across the tires. A car struck by lightning will almost always be found with the occupants unhurt, but with the tires blown or aflame.

A recent accident involving a family of seven and a pickup truck illustrates the point. Lightning struck and critically injured three family members sitting in the pickup bed, while those inside the cab were not even jolted. Again, it is the cloak of metal that gives the protection and not the tires.

Rubber-soled shoes do not protect potential victims from lightning. In fact, individuals struck by lightning usually have their shoes or boots torn or blown off their feet. Rubber soles do not protect victims of direct strikes, but might lessen the jolt of a step voltage.

What To Do When Lightning Comes

When lightning comes, seek shelter, preferably in a structure with lightning protection. Get



A vertical lightning conductor, such as a grounded radio tower, a building, or a power line, will give a zone of protection from a direct strike over a distance equal to one to two times its height. Note the unsafe zone within 3 feet of the conductor, where a side flash can occur. The vertical conductor, unless well grounded, gives little protection from step voltage caused by currents in the ground.

away from water or out of an open field. Avoid taking shelter under an isolated tree or unprotected shed. Move near tall conducting objects like towers or radio antennae, staying at least 2 feet from a tower's legs to avoid a side flash, but within the zone of protection. Remain several feet away from metal rods or wire fences; stay away from power lines because they might fall. Remember, a car or a truck cab is an excellent shelter. Stay inside until the storm is long past. If nothing else is available, crouch down in a group of trees or in a thicket. Stay low (but not prone) until the storm danger is past.

To prevent being surprised by a storm situation, it is a good idea to check area weather forecasts. Most parts of the country are now covered by National Weather Service radio broadcast on 162.4 and 162.8 MHz.

On thunderstorm days, rapidly growing cumulus clouds are warnings of impending lightning. Downward bulges or a column or streak of rain emerging from the cloud base also signal that the cloud has reached a mature state and that lightning is imminent. Sometimes, on high mountains or ridges, strong electric fields can cause dry hair to stand on end and produce a tingling feeling in raised

fingertips. An audible crackling or buzzing may be heard from a portable radio. This is the final warning—the lightning discharge process has started. Drop to a kneeling or crouched position immediately and crawl toward a safe place. Remain down until the danger is past. Although many people are killed each year, about two-thirds of the people involved in accidents will recover with little permanent damage. Most victims will be dazed and partially paralyzed for the moment, but will soon recover. Immediate first aid for victims at the scene is imperative. First attention should be given to persons not breathing or moving. Most victims suffering pulmonary arrest can be revived with a few minutes of artificial respiration. Those suffering cardiac arrest can be kept alive by cardiopulmonary resuscitation (CPR) until professional help is available. All victims can be treated immediately; there is no residual charge or current from the lightning stroke.

Most accidents involving lightning need not happen. With knowledge of lightning behavior, the awesome beauty of a thunderstorm and its dramatic lightning displays can be enjoyed with only minimal risk. But safety requires understanding the phenomenon, planning ahead, being alert and observant, and acting decisively when necessary. ■

Northeastern Compact Fire Exercise

Richard E. Mullavye

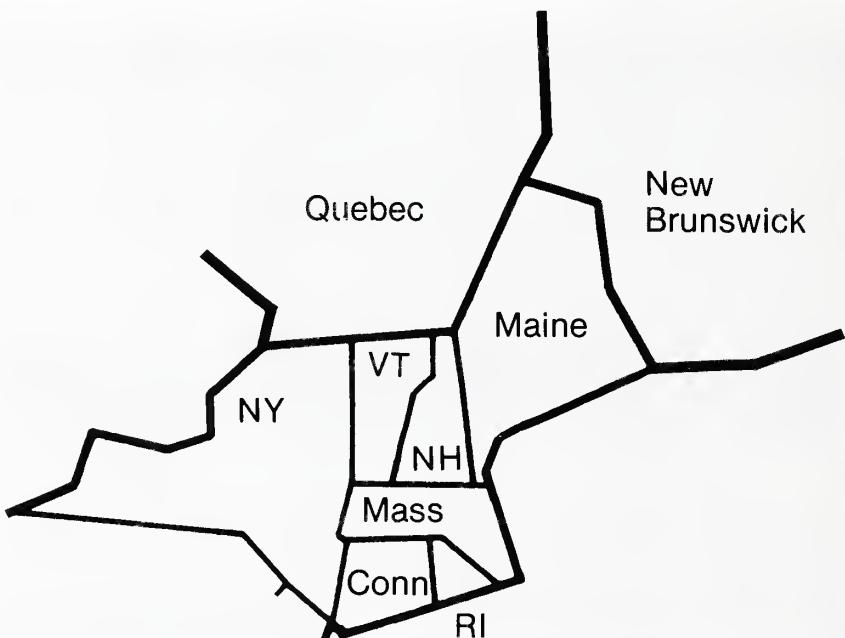
Executive Director, Northeastern Forest Fire Protection Compact, Concord, N.H.

Mutual aid is the primary reason to belong to a forest fire protection compact. But the commissioners and firefighting personnel of the Northeastern Forest Fire Protection Compact faced a dilemma: How do you practice mutual aid, if you do not regularly have large fires to practice on? They agreed that a practical exercise was one way to achieve and maintain mutual aid readiness.

But the Northeastern compact embraces Connecticut, Rhode Island, Massachusetts, New York, New Hampshire, Vermont, and part of New Brunswick and Quebec. So what is the most desirable location to hold the exercise? How much equipment and personnel is necessary? And how does the host State benefit if they do not have an opportunity to send equipment and personnel to another State?

To meet the needs of all concerned, the compact put on two exercises at two locations. This cut down on travel by providing closer, more centralized locations for each half of the compact to travel to and permitted the host States to travel to the other half's fire exercise. Equipment requests were made but compact members were required to send only samples.

The compact member States were notified in advance that there



The Northeastern Forest Fire Prevention Compact embraces Connecticut, Rhode Island, Massachusetts, New York, New Hampshire, Vermont, and part of New Brunswick and Quebec.

would be a practical exercise between September 12 and 25. (Some date period was necessary in order to finance nonemergency travel.) They were not given prospective dates, times, or dispatching needs, and they were not told that there would be two exercises. They were told they would be required to send only samples of requested equipment but were asked to go through the paperwork process when the request calls came.

On Thursday, September 16, the compact executive director placed the first dispatch call to New Brunswick at 0623. Calls to Massachusetts, Vermont, New Hampshire, and Quebec followed with orders for personnel and equipment to report to fire headquarters at the White Mountain National Forest Ranger Station at Bethel, Maine. Ranger Mark Boche, U.S. Department of Agriculture, Forest Service, provided space and telephones for

the exercise area. Specific tools and equipment were ordered and a sector boss or water handling specialist was summoned.

Periodic reports were phoned to Bethel, Maine, as orders were filled and estimated times of arrival determined. At the Bethel headquarters, training committee co-chairman Jack Sargent at New Hampshire and Al Willis of Maine checked-in arriving shipments. Equipment committee member Terry Trudell of Maine inspected equipment. An appropriate test was given to each sector boss and water handling specialist after they checked in. The executive director was informed of arrival and release times, and States supplying personnel and equipment were notified of arrivals.

On Tuesday, September 21, the second exercise took place. Fire headquarters was Erving State Forest Headquarters in Erving, Mass. Dispatch calls to Connecticut, New York, Rhode Island, and Maine started at 0805. Again, specific equipment requests were made and sector boss or water handling specialist summoned. Sargent and Willis again took charge of the headquarters operation, with equipment committee chairman Bob Burton of New Hampshire inspecting equipment. The same system of communications between dispatcher, supplier State, and

receiver used in the previous exercise was utilized.

Results of the exercises were generally favorable. Personnel and equipment were requested by mid-afternoon. Arrivals were timely and materials arrived as specified.

The problems that were encountered will be reviewed at our annual training meeting, and workshop groups will recommend solutions, as well as procedures for future exercises. The problems include: the questionable quality of some supplies, particularly hoses; the need for proper ownership identification on equipment; the lack of equipment manifests; the language barrier because both English- and French-speaking firefighters participated; the dissimilar qualifications among specialists; the difficulties encountered in tracking down participants; and busy telephone lines. ■

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News and Notes

McCarty Throttle Control

Forest Technician John McCarty has solved a problem that has plagued the Pennsylvania Bureau of Forestry's airtanker operations each spring for several years. He has designed, constructed, and field-tested an automatic hydraulic throttle control that reduces the speed of the pump engine to control the pressure in loading hoses.

The Pennsylvania Bureau of Forestry operates two airtanker bases for the fire season each spring. A problem at each base has been the untimely rupturing of the loading hose, which is usually caused by exceeding pressure limitations when the nozzle is closed with the pump at full throttle.

Each base utilizes 3-inch Spiraflex Pliovic compound hose. The hose has a pressure rating of from 55 to 95 lb/in². The Hale 25FA pumps used at both bases produce in excess of 115 lb/in² when at full throttle. In order to avoid bursting the hose during loading operations, it has been necessary to either employ two people (one at the pump and the other at the nozzle) or to require one employee to make several trips between pump and aircraft during one loading operation. The first alternative is expensive. The second obviously increases the



The materials needed to make the throttle control device.

safety hazard and reduces efficiency.

McCarty's throttle control solves the problem. During loading operations, when the pump is at full throttle and the loading nozzle is in the open position, in-line pressure is near zero. At the completion of loading, the nozzle is moved to the closed position and in-line pressure mounts. When pressure exceeds 20 lb/in², the throttle control automatically reduces the pump to idle speed. When the nozzle is opened again, the device allows the pump engine to return to the full throttle position.

Materials needed to make the throttle control device are: a 5/16-inch petcock valve; a 1-inch-diameter, 3 1/2-inch overall-length cylinder with a retracting rod; a 10-inch length of 5/16-inch hydraulic hose; and a connecting arm of stainless steel, 7/16 inch wide by 0.020 inch thick by 4 inches long.

The necessary parts are relatively inexpensive and available. For more information, contact the Division of Forest Fire Protection, Pennsylvania Bureau of Forestry, DER, P.O. Box 1467, Harrisburg, PA 17120, or call (717) 787-2925. ■

Warren A. Ely
*Chief, Operations Section
Division of Forest Fire Protection*

About Smoke

A new leaflet offers sound advice about managing smoke from prescribed fires, brush burning, and any type of open burning. The leaflet answers basic questions like what's in smoke? and why do piles of debris present burning problems? Eight guidelines to follow before starting a fire and four guidelines to follow during the burn are listed. A free copy of the leaflet, "About Your Smoke," is available from USDA Forest Service, Information Center, 1720 Peachtree Road, NW, Suite 816, Atlanta, GA 30367. ■

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